frequent failure of the physician to recognize cancer of the stomach sufficiently early for the surgeon to effect a cure will in the future be immaterial, owing to the success of the practitioner in preventing its development.

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TREATMENT OF CHRONIC INFLAMMATORY DISEASES OF THE MOUTH, PHARYNX, AND LARYNX BY LOCAL APPLICATION OF ULTRA-VIOLET RAYS

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The object of this paper is to record some results following the treatment of inflammatory diseases of the mucous membrane of the mouth, pharynx, and larynx by means of the local application of ultra-violet rays emitted by a specially designed "throat lamp."

During the past fifteen years Strandberg, working at the Finsen Light Institute at Copenhagen, has recorded successful results in the treatment of tuberculous disease of the larynx, following the exposure of the skin of the whole body by general irradiation to the ultra-violet rays of the carbon arc. Cemach and de Wesselow have designed special quartz rod applicators attached to the water-cooled Kromayer lamp or to the carbon arc of the Finsen type, for the local application of ultra-violet rays to the larynx. Similar quartz silvered mirrors for the reflection of rays and other apparatus have been designed. All these apparatuses are cumbersome, and necessitate long exposures to the source of light, and this makes treatment tedious and tiresome for the sick patient.

In 1926 I designed a small water-cooled quartz mercury vapour lamp for the direct application of ultra-violet rays to the buccal cavity, the tongue, pharynx, and larynx. This apparatus was demonstrated in 1929 to the Section of Laryngology of the Royal Society of Medicine. Since then I have treated over sixty patients. The technique which is described is based upon my results and observations made during the treatment of these selected cases. The pathological conditions which have been treated may be classified under the following groups:

1. Chronic tuberculous ulcers of the tongue and palate.
2. Chronic tuberculous disease of the larynx.
3. Chronic glossitis and inflammatory ulcers of the tongue (leucoplakia).
4. Chronic inflammatory lesions of the pharynx and nasopharynx.

The value and scope of the treatment of many diseases of the mouth, pharynx, and throat by local ultra-violet irradiation is as yet little known to many oral surgeons and laryngologists. It is hoped that the extended clinical trial of this technique of treatment will confirm my results, and help to establish a valuable additional method of treatment for lesions which often resist other established methods.

TECHNIQUE OF METHOD

THE APPARATUS

This throat lamp was designed so that it could be easily inserted into the mouth, and could be brought by direct application to the pillars of the fauces, the post-nasal space, the pharynx, or the larynx. The lamp is essentially a small water-cooled "vacuum type" quartz mercury vapour lamp, and consists of three parts: (1) a quartz mercury vapour vacuum high-pressure burner; (2) a quartz water-jacket; and (3) a metal jacket, to which the burner is cemented, and which contains water-cooling apparatus, and also insulated leads carrying the electric current. The quartz burner is U-shaped and bent at its horizontal axis to an angle of 160 degrees. It is made of a thick-walled quartz tubing about

QUARTZ MERCURY VAPOUR THROAT LAMP

A, Burner and metal holder; B, quartz water-jacket; C, metal jacket; D, water-tubes; E, insulated leads. (The diagram is not drawn to scale.)

1.5 mm. in diameter. The internal diameter of the quartz tubing is 0.5 cm. One of the limbs of the U-tube is dilated at its terminal end. The burner is constructed on the same principle as the high-pressure-vacuum mercury vapour lamp, and operates on an electric current of 1 to 1.5 amperes and 80 to 120 volts between the electrodes (direct current only). The water-jacket is made of quartz, and is the shape and size of the adult thumb. It fits over the quartz burner and is oval in shape, measuring 6 x 3 x 2 cm., leaving a space of 0.5 cm. surrounding the quartz burner in every direction. The jacket is made to taper gradually as its closed extremity; the open end is widened and made circular, so that it can fit tightly to the metal holder by means of a rubber washer and a circular screw cap. The jacket can easily be removed, and in this way the quartz burner can be thoroughly cleaned and a differently shaped jacket can be attached when necessary. The metal holder is made of nickel-plated metal and is circular in shape, roughly 3 cm. in diameter and 15 cm. in length. The quartz burner is soldered and cemented into this holder, and the electrodes are carried through it, being well insulated with rubber and non-conducting composition, and fused to two copper electric wires, also well insulated, so

as to carry the electric current from the electrodes and burner. In this way the conducting leads and electrodes are thoroughly insulated and made watertight. Two metal tubes 3 mm. in diameter are also carried through the metal holder for the circulation of water and cooling of the burner. One is an inlet tube, and passes into the cavity of the water-jacket for 3 to 4 mm.; the other is an outlet tube. The inlet tube is connected by strong rubber tubing to a water tap, and the outlet tube has a rubber tube passing to a sink or basin. In a recent model apparatus I have designed an electrical motor water-pump is connected to a reservoir containing distilled water, and thus the lamp is cooled by the motor pump forcing water through its inlet and outlet tubes. The circulation of water must be thoroughly efficient, and the lamp must be tested every time before it is used for treatment. It must be perfectly cold when grasped by the hand after running for five to ten minutes. The danger of overheating or insufficient cooling of the lamp is important, for as a result the mucous membrane may be damaged and seriously burned. Further, the lamp will be overrun and the seals of the electrodes will melt and be destroyed. It is therefore essential to carefully check the cooling mechanism of the lamp.

PHYSICAL NATURE OF RAYS EMITTED

The lamp emits luminous and ultra-violet rays of wave-length from about 8,000 to 2,300 A.U. The infra-red and heat rays are completely absorbed by efficient water circulation. The spectrum of the lamp has the same characters as the quartz mercury vapour lamp, but is of relatively weaker intensity, since only an electric current of 80 to 100 volts and one ampere is transmitted. For this reason it is seen that the shorter ultra-violet rays in the region of wave-length 2,500 A.U. are relatively weaker in intensity and the longer ultra-violet rays in the region of wave-length 2,700 A.U. are stronger in intensity than those usually transmitted by the ordinary mercury vapour lamps working at an electrical potential of 2.5 amperes and 150 volts.

MANIPULATION OF LAMP

Before the lamp is started the water is made to circulate and completely fill the jacket; all air bubbles must be cleared. The current is switched on and the lamp started by tilting; the arc should burn evenly in both limbs of the U-tube, and if the mercury column is uneven the lamp should be switched off and restarted until the columns are even and equal in both limbs. After it has been running steadily in a horizontal position for two to three minutes the arc is established, and the lamp will then keep alight when held in any position. Its outer surface must always be thoroughly clean, and this can be secured by employing a weak solution of acid, which must be washed and cleared by water before use. Rays from either the upper or lower surfaces, or the end of the lamp, can be used alone, by covering the remaining portions with small pieces of lead foil fixed by elastic bands. This is useful when only the tongue, palate, or the right or left tonsillar fossa is to be irradiated; the remaining areas of mucous membrane can be easily protected from the rays by such simple means. After treatment is completed the lamp is cleaned by washing in water and rectified spirit, and then allowed to burn for two or three minutes, for the ultra-violet rays emitted have direct bactericidal action, and in this way the lamp is automatically efficiently sterilized.

DETAILS OF ADMINISTRATION

The area which is to be irradiated and the surrounding mucous membrane of the pharyngeal wall should be anaes-

thetized by a local anaesthetic. I usually employ a 5 per cent. or 10 per cent. solution of cocaine hydrochloride in saline sprayed on the mucosa by means of a Devilbiss spray attached to a motor air-pump. This is a rapid and efficient method, and local swabbing of the mucosa or local injection of the palate or pillars of the fauces is rarely necessary. The use of synthetic anaesthetics such as novotox, etc., is not suitable for the purposes of ultra-violet therapy, as they contain a quinoline base and other chemical compounds, which absorb short ultra-violet rays, and inhibit their biological action on the mucosa. The operator should always wear an efficient mask and a pair of spectacles, so as to be protected from any sudden spasm of coughing, and also from the ultra-violet rays, which might otherwise cause inflammatory reaction of the conjunctiva. The patient should wear a pair of dark-tinted spectacles to protect the eyes against the irritative action of ultra-violet rays; he should be seated in a comfortable rather low chair, be put at ease, and made to relax as much as possible. The operator should stand facing the patient. The operative procedure should be fully explained beforehand, so as to obtain the help and co-operation of the patient during the treatment. The patient is told to open the mouth and protrude the tongue, and to breathe deeply and slowly through the mouth. The tongue is grasped with the thumb and middle finger of the left hand and firmly supported. The lamp is now directed towards the base of the tongue or to the lesion, and as the grasp of the tongue is relaxed the lamp is finally placed in contact with the lesion, and simultaneously the patient is told to withdraw the tongue. Once the lamp is in its proper position the patient's head is bent forward and downward and the lips are made to enclose the lamp. This procedure should take less than five seconds, and should be carried out so as to avoid any retching, coughing, or straining. The patient is then made to relax as much as possible and to take slow, deep breaths through the mouth, in harmony with the operator, who counts aloud with each inspiration. In this way the dosage is checked and regulated by the operator, though it should also be checked by means of a time clock. If the patient is uncomfortable, and coughs or strains, the lamp should be withdrawn and the whole procedure be started *de novo*. A little education and encouragement soon makes the technique of treatment a comfortable and fairly simple procedure.

DOSAGE AND EFFECTS

The mucous membrane of the buccal and pharyngeal cavities is three to four times as sensitive to ultra-violet rays as the normal white skin. By direct contact of this quartz lamp to the normal white skin an erythema reaction is produced after sixty seconds' exposure. The erythema dose for the normal mucous membrane is ten to fifteen seconds. This dose of ultra-violet rays applied to the mucous membrane of the posterior pharyngeal wall, or to the pillars of the fauces, will cause a visible redness of the mucosa twenty-four to forty-eight hours after irradiation. After treatment the patient will experience a dryness and irritation of the throat, somewhat similar to a sore throat, and swallowing may be painful. The reaction starts after a latent period of twelve hours, and increases to its maximum after forty-eight hours, when it gradually subsides. More intensive reactions occur with increased dosage or abnormal sensitiveness of mucosa. This is seen in a diffuse redness, swelling, and oedema, and the mucosa may gradually become increasingly oedematous. The swelling may spread to the uvula, the pillars of the fauces, and in the larynx, and may even cause oedema of the vocal cords and epiglottis. The reaction reaches a maximum after forty-eight hours, and

makes swallowing painful, with irritation of the throat. This intensive reaction may cause general malaise and pyrexia (100° – 101° F.), and in such cases the patient should be put to bed at rest for twenty-four to forty-eight hours, and a menthol carbolic gargle and a light, semi-solid, tepid or cold diet prescribed. The oedema invariably subsides after forty-eight hours, and so far has never needed any other treatment.

This reaction is more common when treating subacute inflammatory conditions of the pharynx or tonsils, or when intensive treatment is applied in tuberculous lesions. Some types of the haemolytic streptococcal infections of the mucosa may give rise to a severe reaction, even with mild irradiation, and may cause redness and oedema of the whole palate, and severe reaction for twenty-four hours. Similar reactions have been observed in cases of Vincent's angina, but often the presence of chronic disease of tonsils and hidden septic crypts may cause this undue reaction. The mucosa of the patient who has a "gouty diathesis," with a markedly acid saliva, is often more sensitive to ultra-violet rays than others, and in such cases treatment must be started with extreme caution, with half or a quarter "mucosa erythema" dosage. It is better to give treatment daily or on alternate days in these types of sensitive cases, and gradually work up to the erythema reaction, for the sudden acute reaction may be alarming and distressing to the patient. When this severe reaction subsides beneficial results may follow. After the erythema reaction the mucous membrane settles to normal within five to seven days, and shows a rapid hardening to ultra-violet rays, inasmuch as the dosage at the second, and subsequent, treatment may be increased to 15–30–60 seconds, and only cause mild inflammatory reactions. In the treatment of chronic tuberculous and other inflammatory conditions of the palate and larynx a full erythema and blistering dose of rays is intentionally applied locally at the site of the lesion, all other areas being shielded from the rays by covering the lamp with metal foil. Following the oedema and erythema of the mucosa round the site of the lesion, a yellow white slough may appear five to six days later, which gradually separates within ten to fourteen days. The exudative reaction is obtained with twice or three times the average erythema dose, but dosage must be carefully controlled and determined by the density and infiltration of scar tissue, and the nature of the ulceration at the site of the lesion. Enlargement and swelling of the cervical lymph glands may follow from intensive local irradiation of the mucosa. This subsides within five to seven days. The painful symptoms following the application of ultra-violet rays may be relieved by the local application of infra-red and luminous rays to the skin area of the neck at the site of pain.

The subsequent dosage is increased according to the technique of treatment which is to be adopted. The first treatment is applied so as to test the sensitiveness of the mucosa to ultra-violet rays, and the dosage is accordingly controlled by these observations. Intensive local treatment is applied once every seven to fourteen days, varying with the duration and severity of the reactions following irradiation. When intensive treatment is applied the patient must be warned, and adequate arrangements for rest in bed, careful nursing, and diet may be necessary. Intensive local treatment should not be applied unless the general resistance of the patient is fairly good, as constitutional reactions may follow. In such cases I usually advise general ultra-violet irradiation of the body two or three times a week for two weeks prior to the application of the local irradiation treatment to the throat. In the cases which have been under my care I have only experienced severe constitutional reactions after treatment of subacute tuberculous disease of the larynx, associated with

miliary dissemination of active tuberculous disease of the lungs, and I am now of the opinion that such cases are unsuitable for local irradiation therapy.

THERAPEUTIC ACTION ON MUCOUS MEMBRANE

The reaction of the tissues following the absorption of ultra-violet rays may cause gradual healing of a diseased lesion, owing to the local changes in the capillary blood vessels. A prolonged hyperaemia and vaso-dilatation is produced for five to seven days following irradiation; this is associated with stimulation and emigration of leucocytes, and exudation of lymph and fibrin. It is now well established that the direct bactericidal action of ultra-violet rays destroys surface bacteria and living filter-passing viruses, and although the penetration of the bactericidal rays is small the effects may be sufficient, and the absorption of such irradiated bacteria may increase the local resistance of the tissues, and may also increase general and specific immunity. The absorption of photo-biochemical substances produced by the irradiation of living cells may also add to the increase of the immunity force of the body. In the treatment of disease of the larynx no effort has been made to concentrate ultra-violet rays directly to the lesion, but the rays emitted by the "throat lamp" have been applied to the opening of the larynx as a whole. The reaction which followed has involved, and spread beyond, the irradiated area, and at times has produced the greatest inflammatory changes at the site of the lesion. Healing has continued progressively. It is difficult to decide if the inflammatory reaction produced at the site of the lesion is in itself sufficient to cause this healing, or if the immunity mechanism of the body has been activated locally at the site of irradiation, or if the absorption of irradiated bacteria and irradiated tissue cells by a new vascular field has caused local increase of resistance and stimulation of the immune forces of the body.

OBSERVATIONS ON SELECTED GROUPS OF CASES

Chronic Tuberculous Disease of the Palate and Tongue.

—This responded very well to treatment. In all, three cases were treated. In each there was an old history of tuberculous disease of the lungs, but this was well healed and fibrosed before the patients came for treatment. Intensive local treatment was applied to the lesion once every fourteen days, and in one case it was also possible to administer general ultra-violet irradiation twice a week. The dosage of local treatment started with fifteen seconds, and was increased during subsequent treatments to two minutes. Each local application of ultra-violet rays was made by direct contact of the lamp to the site of the lesion. Erythema and oedema followed twenty-four hours later, and spread to the surrounding margins of the ulcer, causing pain and soreness of the tongue and palate. Healing occurred after five or six treatments, giving a smooth, pale scar with little contraction of the mucous membrane. Two of the patients have now been healed for over five years. The third had had previous x-ray treatment, and the tuberculous ulcer of the tongue was indurated with hard scar tissue; this increased the resistance of the tissue to ultra-violet rays and delayed healing, and the dosage of ultra-violet rays had to be increased to ten minutes.

Chronic Tuberculous Disease of the Larynx.—Eight cases have been treated, six with successful results—restoration of voice and healing of ulcerated areas. Two patients died, but in these there was intensive involvement of both lungs, and treatment was only applied in an attempt to relieve dysphagia and painful symptoms. In these two cases there was evidence to show that the

local application of ultra-violet rays to the larynx had a sedative and analgesic effect which was of comfort to the patient, for although the reaction following treatment caused erythema and oedema, the oedema appeared to alleviate the painful symptoms for a time, and local anaesthetic spraying and gargles were unnecessary for a short time following treatment.

The mucous membrane of the palate, pharynx, and surrounding areas was anaesthetized, and the lamp was inserted beyond the base of the tongue, so that rays of light were directed to the opening of the larynx. The upper surface of the lamp was covered with lead foil so as to protect the uvula and soft palate from direct radiation. The first treatment was applied for ten to twelve seconds; the patients were made to breathe deeply and slowly while the lamp was applied to the opening of the larynx. Reaction of the mucous membrane to ultra-violet irradiation was seen twenty-four to forty-eight hours later, and this caused redness and swelling of the post-pharyngeal wall. Oedema extended to the soft palate and uvula, although these areas were shaded from direct radiation. Laryngoscopic examination showed redness and swelling involving the epiglottis, vocal cords, and arytenoid cartilages. The patients complained of soreness of throat, dryness, and pain on swallowing. Earache occurred when the irradiation reaction spread to the posterior pillars of the fauces. Symptoms subsided three to four days following irradiation, and were relieved by gargles, spraying of the throat, local application of infra-red and luminous rays, and rest in bed for twenty-four to forty-eight hours. In each of these cases under treatment there was evidence of ulceration, swelling, and oedema, and inflammatory granulation tissue of one of the vocal cords, epiglottis, or arytenoid cartilages. Healing occurred progressively, with restoration of voice, loss of symptoms, and improved general health.

The cases recorded are not sufficient for statistical classification, but the encouraging and successful results should stimulate further clinical research and investigation on larger groups of selected cases.

Subacute Glossitis and Ulcers of the Tongue.—These lesions are due to chronic inflammatory streptococcal infections, and responded favourably after three to four local applications of ultra-violet rays, but the tendency to recurrence was not arrested. The lesions were a secondary manifestation of some other primary focus of infection. The local treatment checked the pain and caused healing within three to four days, but all the cases I treated had recurrences of ulceration of the tongue and mucosa in other sites several months later. Four cases were treated.

Chronic Leucoplakia.—Although only two cases were treated these have responded well to intensive local application of ultra-violet rays, and have been successfully

Both were of undiscovered aetiology. Greater should be made of this method of treatment in conditions of leucoplakia, for it should prove of help if carried out in conjunction with specific medicinal treatment in cases of syphilitic origin. Considerable caution is needed if there is suspicion of early malignant disease, for in such cases ultra-violet radiation is strongly contra-indicated, as there is danger that the malignant tissue growth may be accelerated by ultra-violet rays.

Chronic Catarrhal Pharyngitis.—Forty-three cases were treated. Successful results have been obtained in obstinate chronic pharyngitis and nasopharyngeal catarrh which have resisted other therapeutic measures—that is, local sprays, medication, vaccines, cauterization, etc. Suberythema or mild erythema doses of ultra-violet rays were applied once every week to the pharynx, the nasopharynx, or the tonsillar fossae. Usually three or four local treatments were sufficient to alleviate symptoms of catarrh, cough, or hoarseness of voice. Clinically, definite healing of the mucosa was seen, and areas of chronic oedematous inflammatory tissue of the post-pharyngeal wall and red eczematous patches of the mucosa of the anterior pillars of the fauces improved, showing a pink

and greyish-white smooth area. Thickening of scar tissue or contraction of the underlying tissues was rarely observed.

Observations on the bacteriology of the mucous membrane before and after radiation therapy were disappointing. Before irradiation the cultures taken from the nasopharyngeal, pharyngeal, or tonsillar swabs showed the presence of *Streptococcus haemolyticus* and *Streptococcus viridans*, *Micrococcus catarrhalis*, and Pfeiffer's and Friedländer's bacillus. After irradiation the bacteriological cultures grew the same types of organisms. It was observed, however, in some cases, that during the erythema stages—that is, twenty-four to forty-eight hours after local irradiation—throat and post-nasal swabs often grew a pure culture of a haemolytic long-chain streptococcus, whereas cultures before irradiation grew a non-haemolytic short-chain type of *Streptococcus viridans*. These changes in the bacterial flora are difficult to explain, but the original bacterial flora were seen seven days later.

Caution is necessary in the dosage of local irradiation in cases of Vincent's angina, and also during the treatment of the "gouty mucous membrane"; for severe reaction causing a spreading oedema of the soft palate and uvula may follow, even with mild sub-erythema dosage. The local irradiation of the pharyngeal and tonsillar mucous membranes may be of great value in the treatment of chronic catarrh following colds, and of chronic infections with streptococci, Vincent's angina, and diphtheria carriers, etc. Cases of chronic septic and catarrhal pharyngitis showing clinical signs of redness or oedema of the mucosa, and symptoms of persistent nasopharyngeal catarrh, hoarseness of voice, and troublesome cough, have responded well to radiation therapy after other methods have failed. The results of treatment of many of these cases of chronic pharyngitis are similar to the successful results often obtained following the local irradiation of a patch of chronic idiopathic eczema of the skin or of the external auditory meatus. The treatment of such lesions with full erythema doses of ultra-violet rays will often completely heal a lesion of many years' duration in two to three weeks.

CONCLUSION

The cases which I have treated are relatively few, but I hope that observation and the results of the treatment will encourage further clinical research at hospitals and other clinics, where greater access to suitable cases is available.

The treatment of the mucous membrane by local radiation therapy must be confined to the specialist. The manipulation of the apparatus needs careful and specialized knowledge, and the application and supervision of treatment can only be carried out by fully qualified physicians.

I am greatly indebted to Mr. Douglas Harmer for his help and kindness. During the past two or three years he has contributed some suitable cases for treatment, and checked my observations and results. As he says:

"In the few cases observed the results obtained by this treatment have been surprisingly good. Even a short application of the light for a few seconds only may produce a sharp local reaction, but when applied cautiously the inflammation is never serious or prolonged, and in many instances is followed by rapid improvement. Thus in three cases of chronic laryngeal tubercle the lesions healed much more quickly than I should have expected without light treatment. Several very obstinate cases of pharyngitis have also improved enormously. But the method is comparatively new, and therefore requires careful investigation before one can decide which types of inflammation are best treated by it."

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